cc: Ken
1240.2 J. Coyne

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VII
726 MINNESOTA AVENUE
KANSAS CITY, KANSAS 66101

July 6, 1987

Mr. Rodney R. Nelson
U.S. Department of Energy
Weldon Spring Site Remedial
Action Project/Office
Route 2, Highway 94, South
St. Charles, Missouri 63303

Dear Mr. Nelson:

Ed Skowronski, ATSDR representative working with EPA, reviewed the Biouptake and Sediment Sampling Plans. His comments are as follows:

1. Plan for the Sampling of Sediment Influenced by Weldon Spring Chemical Plant Drainage.

Table 4-1 - Are some of the sample locations truly background?

5.0 - I would like to see more of the QA/QC procedures detailed in the body of the plan.

6.0 - Who will get a copy of the results? Will we get a chance to input into deciding the necessity for cleanup? This is not clear.

2. Plan for Determination of Biological Uptake of Radionuclides and Nitroaromatics in Species in the Food Pathway at the Weldon Spring Site.

Are there any other contaminants that may be expected to appear in the food pathway at the Weldon Spring Site? Page 14, paragraph 2 - FDA procedures for determining edible portions of fish flesh call for filleted with the skin left on. Page 21 - Frogs have been found at other site to have very high levels of contamination. They should probably be included.

Please call Ed at 913/236-2856 if you have any questions or need further information.

Sincerely yours,

Katie

B. Katherine Biggs
Chief, Environmental Review Branch

cc: Robert Morby
Ed Skowronski
David Bedan

001349
7-10-87

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

September 24, 1987

Ms. Katherine Biggs, Chief
Environmental Review Branch
U. S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Dear Ms. Biggs:

WORK PLAN FOR DETERMINATION OF BIOLOGICAL UPTAKE OF WSS CONTAMINANTS BY SPECIES IN FOOD PATHWAYS

Enclosed are four (4) copies of the subject work plan. The sampling effort may begin as early as September 28, 1987. Comments in your July 6, 1987, letter have been incorporated as applicable.

If you have any questions, please call me or Ken Lawver at (314) 441-8978.

Sincerely,

R. R. Nelson

R. R. Nelson
Project Manager
Weldon Spring Site
Remedial Action Project

CE-541:Lawver

Enclosure

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

September 24, 1987

Mr. Dave Bedan
Missouri Department of
Natural Resources
Post Office Box 176
Jefferson City, Missouri 65102

Dear Mr. Bedan:

WORK PLAN FOR DETERMINATION OF BIOLOGICAL UPTAKE OF WSS CONTAMINANTS BY SPECIES IN FOOD PATHWAYS

Enclosed are four (4) copies of the subject work plan. The sampling effort may begin as early as September 28, 1987. Comments in your July 6, 1987, letter have been incorporated as applicable.

If you have any questions, please call me or Ken Lawver at (314) 441-8978.

Sincerely,

R. R. Nelson
Project Manager
Weldon Spring Site
Remedial Action Project

CE-541:Lawver

Enclosure

JOHN ASHCROFT
Governor

[redacted]RICK A. BRUNNER
Director

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL QUALITY
P.O. Box 176
Jefferson City, MO 65102

Division of Energy
Division of Environmental Quality
Division of Geology and Land Survey
Division of Management Services
Division of Parks, Recreation, and Historic Preservation

October 26, 1987

Ms. Katie Biggs, Chief
Environmental Review Branch
U.S. Environmental Protection Agency
727 Minnesota Avenue
Kansas City, Kansas 66101

Dear Ms. Biggs:

The Missouri Department of Natural Resources (MDNR) has reviewed four interim response actions which the U.S. Department of Energy (DOE) has proposed for the Weldon Spring site.

These actions are:

1) Removal of overhead piping and asbestos insulation

2) Disposal of containerized chemicals

3) Remedial action on the Army Reserve Property

4) Power line/pole removal.

The MDNR supports the initiation of these actions at this time with the qualifications noted in the October 26, 1987 letter from Dr. Frederick A. Brunner, Director of MDNR, to Mr. Rod Nelson, Weldon Spring Site Manager. Therefore, MDNR approves initiation of these actions but the DOE should initiate discussions with the MDNR regarding the issues raised in Dr. Brunner's letter, specifically:

1) DOE should provide information to MDNR to allow us to determine whether the on-site handling, processing and storage of solid waste is subject to the Missouri Solid Waste Management Law.

2) When an off-site solid waste landfill is selected for the disposal of asbestos or other solid waste, the landifll operator and the DOE must apply for special waste disposal approval.

3) In regard to containerized chemical waste disposal, the subcontractor's work plan should be submitted to MDNR for review, when it is available.

The MDNR has also reviewed the "Work Plan for Determination of Biological Uptake of WSS Contaminants by Species in Food Pathways." MDNR agrees that this study should be immediately initiated. However, we note that deer, turkey, geese and ducks will not be sampled at this time because of their mobility. While we agree that it would be difficult to interpret sampling results from these species, we believe that further thought should be given to determining whether these species, particularly the waterfowl, might be contaminated by feeding on the site. If any methods of making this determination can be devised, we would recommend further studies at that time.

Please contact me if you have any further questions on these matters.

Sincerely,

DEPARTMENT OF NATURAL RESOURCES

David E. Bedan
Weldon Spring Site Work Group Coordinator

DEB/mjb

cc: Ron Kucera
Carolyn deRoos
William C. Ford
Nicholas A. Di Pasquale
Bill Dieffenbach, DOC
John Crellin, DOH
Rod Nelson, U.S. DOE

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

November 6, 1987

Ms. Katherine Biggs, Chief
Environmental Review Branch
U. S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Missouri 66101

Dear Ms. Biggs:

PLAN FOR DETERMINATION OF BIOLOGICAL UPTAKE OF WSS CONTAMINANTS BY SPECIES IN FOOD PATHWAYS

Pursuant to our discussion on November 5, 1987, we will modify the subject plan to include PCB and Metal Analyses for on-site terrestrial mammal samples.

Regarding your question concerning analysis of off-site fish samples for levels of Ra 226 and Th 230 we do not plan to include such sampling at this time. We base this plan on previous findings of no elevated levels of Th 230 in off-site water bodies. The mobility of Ra 226 is similar to Th 230 and, similarly, we would not expect to find elevated levels of this radionuclide in off-site water bodies. We will add in the Biouptake Plan that if elevated levels of RA 226 or Th 230 are discovered during the upcoming lake and stream sediments sampling program then it will be necessary to analyze for these radionuclides on fish samples designed to represent consumption of fishcake (i.e., including bones). Our plan does include analyses for Ra 226 and Th 230 on fish samples from on-site water bodies.

We appreciate EPA's comments and encourage you to call if you have any further questions.

Sincerely,

SH McCracken

Stephen H. McCracken
Deputy Project Manager
Weldon Spring Site
Remedial Action Project

cc: J. D. Hammond, MK-Ferguson

cc: R. Nelson
S. McCracken
J. Coyne
File

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VII
726 MINNESOTA AVENUE
KANSAS CITY, KANSAS 66101
November 6, 1987

Mr. Rodney R. Nelson
U.S. Department of Energy
Weldon Spring Site Remedial
Action Project/Office
Route 2, Highway 94, South
St. Charles, Missouri 63303

Dear Mr. Nelson:

We have reviewed the revised work plan for determination of biological uptake at the Weldon Spring Site (WSS). Generally, the plan is well written and contains all the necessary elements to reach the stated objectives. We concur with the revised plan and agree you should undertake the sampling as planned. The Missouri Department of Natural Resources (MDNR) also agrees this work should be immediately implemented.

As you prepare the report for this work, there are some items that need more detailed discussion or clarification. These points are addressed in the following comments.

1. It is stated that the data will be used in an Endangerment Assessment under CERCLA, but no reference to a guidance document is given. The specific documents to be used should be referenced.

2. On page 2, reference is made to a "metabolic model," but no reference or other discussion is given concerning the type of model to be used; i.e., computer, pharmacokinetic, etc.

3. The term "uptake" may be erroneously used in this document. What is really being measured are residues of compounds already ingested, distributed, metabolized and/or stored. "Uptake" implies that not only is the exposure quantified but that the metabolic dynamics of the chemicals in question are well understood. We suggest that the term "residue" be used in place of "uptake" to denote that the compounds in tissues are of environmental origin but not to imply that complete information regarding pharmacokinetics under natural conditions are known.

4. The revised work plan does not address on-site sampling for PCBs and metals. Based on our discussion, it is my understanding you plan to conduct these analyses and will send a letter to confirm this.

5. Composite samples made up of cleaned but not filleted fish suggest radium and thorium analysis since the bones would also be present in a fish cake. Your report should address why these anlyses are not included.

6. The difficulty in interpreting the analytical results of nitroaromatic coumpounds in tissue should not necessarily deter you from looking for these compounds. It is correct that biodegradation studies as well as true "uptake" studies appear to be unavailable and recoveries of nitroaromatic compounds may be less than 60 percent. However, the mere presence of nitroaromatics in fish tissues would be of significance. It is suggested that, once the TNT/DNT levels in and around the WSS are sifficiently known, the report evaluate the need for additional biological sampling to analyze tissues for the presence of TNT, DNT and other nitroaromatic residues.

7. The plan cites CLP and other analytical methods; however the plan does not specify any tissue extraction procedures. Also, no analytical laboratory is identified.

If you have any questions regarding these comments, please contact me or Dan Wall.

Sincerely yours,

Katie

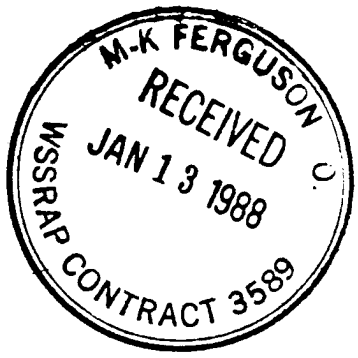
B. Katherine Biggs
Chief, Environmental Review Branch

cc: David Bedan, Missouri Department of Natural Resources

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

3589-88-I-DOE-014

January 13, 1988



Ms. Katherine Biggs
United States Environmental
Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Dear Ms. Biggs:

RESPONSIVENESS SUMMARY ON WSS BIOLOGICAL UP-TAKE SAMPLING AND ANALYSIS WORK PLAN

Enclosed is a responsiveness summary to comments in your November 6, 1987 letter. The final report will reflect responses to the comments and no changes will be made to the sampling plan.

If you have any questions, please call.

Sincerely,

R. R. Nelson
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
As stated

cc: D. Bedan, MDNR
J. Hammond, MK-Ferguson/Document Control

Responsiveness Summary to Comments on the WSS Biological Up-Take Sampling and Analysis Work Plan - Reference: Letter from K. Biggs to R.R. Nelson dated 11/06/87.

Comment No. 1:

It is stated that the data will be used in baseline risk assessment under CERCLA, but no reference to a guidance document is given. The specific documents to be used should be referenced.

Response:

A baseline risk assessment (formerly an Endangerment Assessment) will be conducted to assess the impacts of the no action alternative and the information incorporated into the remedial investigation report. The baseline risk assessment will follow the methodology described in the Superfund Public Health Evaluation Manual.

Comment No. 2:

On page 2, reference is made to a "metabolic model", but no reference or other discussion is given concerning the type of model to be used; i.e., computer, pharmacokinetic, etc.

Response:

Based upon a preliminary review of potential indicator compounds at the WSS, the dominant risk is associated with the ingestion of radiological species. For this reason, the metabolic model used will be that found in the International Commission on Radiological Protection (ICRP) Publications No.'s 23, 26, and 30. All calculations and assumptions will be based on this methodology.

If further evaluation of indicator compounds indicates the need for additional metabolic model(s), the types and rationale for selection of these models will be discussed with EPA before implementation.

Comment No. 3:

The term "uptake" may be erroneously used in this document. What is really being measured are residues of compounds already ingested, distributed, metabolized and/or stored. "Uptake" implies that not only is the exposure quantified, but that the metabolic dynamics of the chemicals in question are well understood. We suggest that the term "residue" be used in place of "uptake" to denote that the compounds in tissues are of environmental origin but not to imply that complete information regarding pharmocokinetics under natural conditions are known.

Response:

The final report will carefully use terms describing the metabolic behavior of the various hazardous substances. The ICRP currently uses the term "uptake" to describe ingestion, distribution and metabolism of radiological species. However, the term "residue" will be incorporated into discussions of compounds in tissue that are of environmental origin in order to not imply complete understanding.

Comment No. 4:

The revised work plan does not address on-site sampling for PCB's and metals. Based on our discussion, it is my understanding you plan to conduct these analyses and will send a letter to confirm this.

Response:

Pursuant to the letter from Stephen McCracken to K. Biggs dated November 6, 1987, analyses for PCBs' and CLP metals for on-site terrestrial mammal samples will be performed. The results will be presented in the final report, however, we do not envision modification and formal reissuance of the work plan document.

Comment No. 5:

Composite samples made up of cleaned but not filleted fish suggest radium and thorium analysis since the bones would also be present in a fish cake. Your report should address why these analyses are not included.

Response:

Previous samples of the surface water in off-site water bodies showed no elevated levels of Ra-226 or Th-230 present. In addition, no elevated levels of Th-230 in sediment from Lakes 34, 35 and 36 and the Femme Osage Slough have been detected in previous preliminary sampling efforts and the mobility of Ra-226 is similar to Th-230. A more intensive Stream and Lake Sediment Sampling Plan is to be initiated in the winter/spring of 1988. Should elevated levels of Ra-226 or Th-230 be discovered during this upcoming program, then the biological uptake plan will be revised to collect and analyze for these radionuclides on fish samples designed to represent consumption of fish cake (i.e., including bones). The current work plan does include analyses for Ra-226 and Th-230 on samples from on-site water bodies.

Comment No. 6:

The difficulty in interpreting the analytical results of nitroaromatic compounds in tissue should not necessarily deter you from looking for these compounds. It is correct that biodegradation studies as well as true "uptake" studies appear to be unavailable and recoveries of nitroaromatics compounds may be less than 60 percent. However, the mere presence of nitroaromatics in fish tissues would be of significance. It is suggested that, once the TNT/DNT levels in and around the WSS are sufficiently known, the report evaluate the need for additional biological sampling to analyze tissues for the presence of TNT, DNT and other nitroaromatic residues.

Response:

Once the nitroaromatic levels in and around the WSS are sufficiently known, the final report will evaluate the need for additional biological sampling to analyze tissues for the presence of these compounds.

Comment No. 7:

The plan cites CLP and other analytical methods; however the plan does not specify any tissue extraction procedures. Also, no analytical laboratory is identified.

Response:

The analytical laboratory which will perform the analyses on samples collected for the biological uptake work plan is metaTrace, in St. Louis, MO. This laboratory has performed the majority of analyses for all determinations made at the WSS in 1987. The laboratory participates in the Contract Lab Program and meets USATHAMA requirements. We would be glad to provide more details on the Quality Assurance and other capabilities of this laboratory at your request.

Tissue extraction procedures are based on guidance provided in the EPA Interim Methods for the Sampling and Analysis of Priority Pollutants in Sediments and Fish Tissue. Modifications to these procedures were made to improve detection limits and percent recovery. These procedures will be cited in the final report.

4728

WORK PLAN FOR DETERMINATION OF BIOLOGICAL UPTAKE OF WSS CONTAMINANTS BY SPECIES IN FOOD PATHWAYS

PREPARED FOR:

U.S. DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS OFFICE

UNDER CONTRACT NO. DE-AC05-86OR21548

PREPARED BY:

MK-FERGUSON COMPANY

AND

JACOBS ENGINEERING GROUP, INC.

ROUTE 2, HIGHWAY 94 SOUTH

ST. CHARLES, MISSOURI 63303

SEPTEMBER 16, 1987

TABLE OF CONTENTS

FIGURES

1.0 INTRODUCTION

The Weldon Spring Site (WSS) is a U.S. Department of Energy (DOE) surplus facility located in St. Charles County, Missouri. This document presents a description of the study plan and scope of work to determine and characterize the level of potential human exposure to radionuclides, polychlorinated biphenyls (PCB's), and EPA-CLP Metals from the food pathways at the WSS. This will be accomplished by a statistically representative sampling effort of biota available for human consumption from various locations around and within the WSS. The final report will describe the methods used in performing the survey, summarize the results, and discuss their significance. This effort is fundamental in providing data used in an Endangerment Assessment as part of an RI/FS process under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

The analysis of the food pathways for the surrounding population is necessary in assessing the risks to human health from pathway ingestion of biota living in or near contaminated sediments and water. Chemical and radiological exposure in humans and the relevance of data in establishing design and action limits will be reviewed.

The study will combine estimates of average consumption by humans with measured contamination levels in edible tissues for input into a metabolic model. The approach taken will measure the actual uptake by edible aquatic and terrestrial biota and then calculate the human uptake from consumption of contaminated tissue based on assumed ingestion rates.

The goal of the sampling is to collect approximately thirty-nine (39) kilograms of sunfish, twenty-eight (28) kilograms of catfish, two (2) kilograms of minnows, sixteen (16) kilograms of largemouth bass, five (5) kilograms of crappies, thirty-two (32) kilograms of frogs, and a minimum of seven (7) kilograms of both rabbits and squirrels.

Electrofishing methods will be utilized for the collection of aquatic samples. This method will provide randomness in fish samples. Individual samples weighing approximately less than 50-75 grams will not be kept, assuming these samples would not be kept for consumption by typical members of the public and uptake would be minimal compared to more adult samples. Frogs will be collected using hand-held nets.

Terrestrial biota samples will consist of small mammals such as rabbits and squirrels. Live traps will be used for the capture of these mammals. Since the population of these

mammals is limited, the traps will be set adjacent or above the areas of contamination. The samples collected will be assumed to live and intake representative amounts of contaminants for populations living near the site(s).

Deer, turkey, geese, and ducks will not be sampled at this time. These animals are very mobile, readily moving on and off the Weldon Spring Site. For this reason, it would be extremely difficult to interpret both positive and negative results since no estimate of the percentage of their time spent on site can be substantiated.

Investigations of offsite radiological migration in soil and water have focused on uranium, due in part to its higher solubility and quantity compared to the other radionuclides present at the WSS. These uranium compounds are also soluble in the body and will incorporate into the soft tissues and bone. Thus, all onsite and offsite samples will be analyzed for uranium.

Surface water outfall sample results from the WSS have background concentrations of radium and thorium. Radium and thorium compounds are insoluble and incorporate primarily in the bone. Therefore, samples from the offsite waterbodies will not be analyzed for radium and thorium because their

uptake in tissue samples are expected to be below detectable levels.

Composite samples collected from the Raffinate Pits, Frog Pond, Quarry Sump, Lake 37, and from small mammals will be analyzed for radium and thorium. Detectable quantities of radium and thorium may exist in the onsite samples due to the higher concentrations of the radionuclides in the waterbodies.

One composite fish sample from each off-site water body will also be analyzed for PCB's and CLP metals. Since the WSCP was operational at a time when PCB's were routinely used, the potential exists for the presence of the contaminants. Many of the old electrical transformers contain PCB's in varying concentrations. In addition, ongoing investigations have indicated PCB's to be present in low concentrations on floors, equipment, and in hydraulic lines at the WSCP. These releases were a result of accidental spills and careless use, not routine releases due to operational procedures.

Draft versions of the Biological Uptake Plan included the analysis of biota samples for nitroaromatics. This was based on the potential for the laboratory to perform such

analyses. Subsequent research indicates the general lack of knowledge about the uptake and bio-degradation and metabolism of nitroaromatic compounds by animals and humans. It would, therefore, be very difficult to interpret analytical results. Second, there is no accepted methodology for analysis of nitroaromatic compounds in tissue. Recovery of target compounds following accepted extraction procedures is expected to be extremely low. In addition, bio-degradation products may not be detected and the lower limits of detection will not be low enough to consistently detect the concentrations anticipated. Therefore, nitroaromatic analyses have been deleted from this plan.

The additional analyses of semi-volatiles were considered, but were discounted for the same factors as discussed for nitroaromatics. Sufficient information concerning uptake, biodegradation and metaboles is inadequate and an acceptable methodology has not been developed.

2.0 SITE HISTORY AND ENVIRONMENTAL SETTING

From 1941 to 1944, the U.S. Department of the Army (DA) operated the Weldon Spring Ordnance Works for production of trinitrotoluene (TNT) and dinitrotoluene (DNT). During this operation, smaller areas of the 17,000-acre site were contaminated by TNT process materials. In the mid-1950's 220-acres of the Ordnance Works property were transferred to the U.S. Atomic Energy Commission (AEC). From 1957 to 1966, the AEC operated a uranium processing facility (Mallinckrodt Chemical Works) at the site. During the operation of this Feed Materials Plant, the buildings, equipment, and immediate terrain of the plant (220-acres) became contaminated with radionuclides in the Uranium transformation series.

After closure by the AEC, the Feed Materials Plant was reacquired by the Army in 1967. The Army partially decontaminated the buildings, dismantled some of the equipment, and began converting the facilities to produce herbicides. In 1969, prior to the Chemical Plant (WSCP) becoming operational, the herbicide project was canceled. In 1985, the custody of the WSCP was transferred from the DA to the Department of Energy (DOE). In conjunction with this transfer, the Weldon Spring Site Remedial Action Project (WSSRAP) was created as DOE Major Project Number 182.

Surface water runoff from the north and west sides of the 220-acre WSCP, as well as potential overflow from an onsite water tower, flow to Ash Pond (Figure 1). Water from Ash Pond travels through an overflow conduit for approximately 100 m, surfaces, and then flows to Lake 35 on the August Busch Wildlife Area, to Schote Creek, Dardenne Creek, and eventually the Mississippi River (Figure 2). Lake 35 is the closest lake receiving effluent from Ash Pond in an unrestricted area. Lake 35 is used for recreational activities such as fishing and boating.

Water from Ash Pond also discharges via underground connections to Burgermeister Spring, Lake 34, Dardenne Creek, and eventually the Mississippi River. At present, there is no recreational use of Burgermeister Spring, but Lake 34 is used for recreational purposes similar to Lake 35. Lakes 34 and 35 are not used as drinking water or irrigation sources. Since operations in 1967 ceased, the discharge from Ash Pond has become an intermittent stream.

Surface water runoff from the northeast portion of the WSCP drains into Frog Pond. An intermittent stream out of Frog Pond flows north to Lake 36. The outfall of Lake 36 discharges into Lake 35, Schote Creek, Dardenne Creek, and eventually the Mississippi River. Lake 36, located in the Busch Wildlife Area is the closest lake receiving effluent from Frog Pond in an unrestricted area. Lake 36 is also

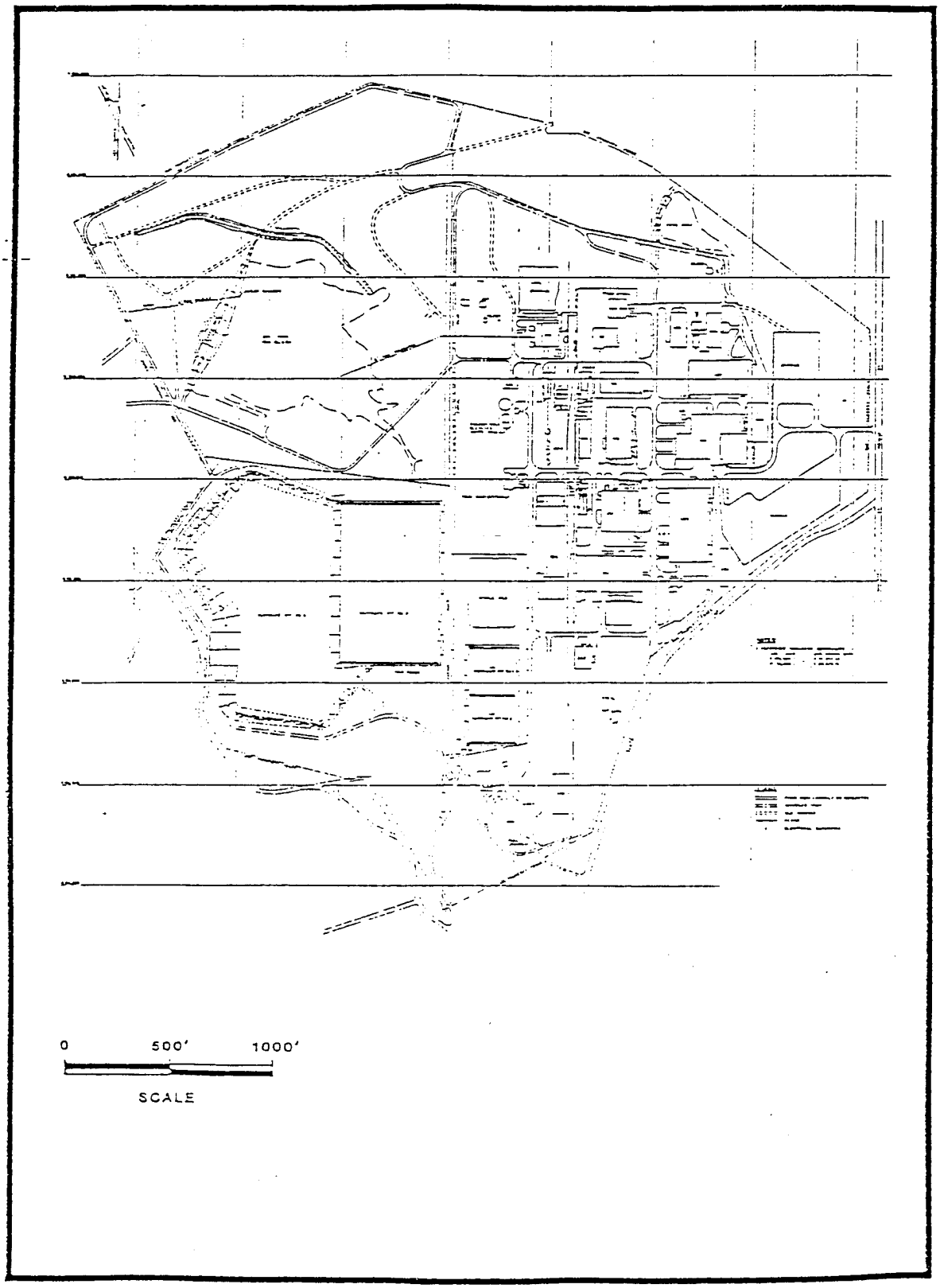


FIGURE 1
MAP OF WSCP/WSRP

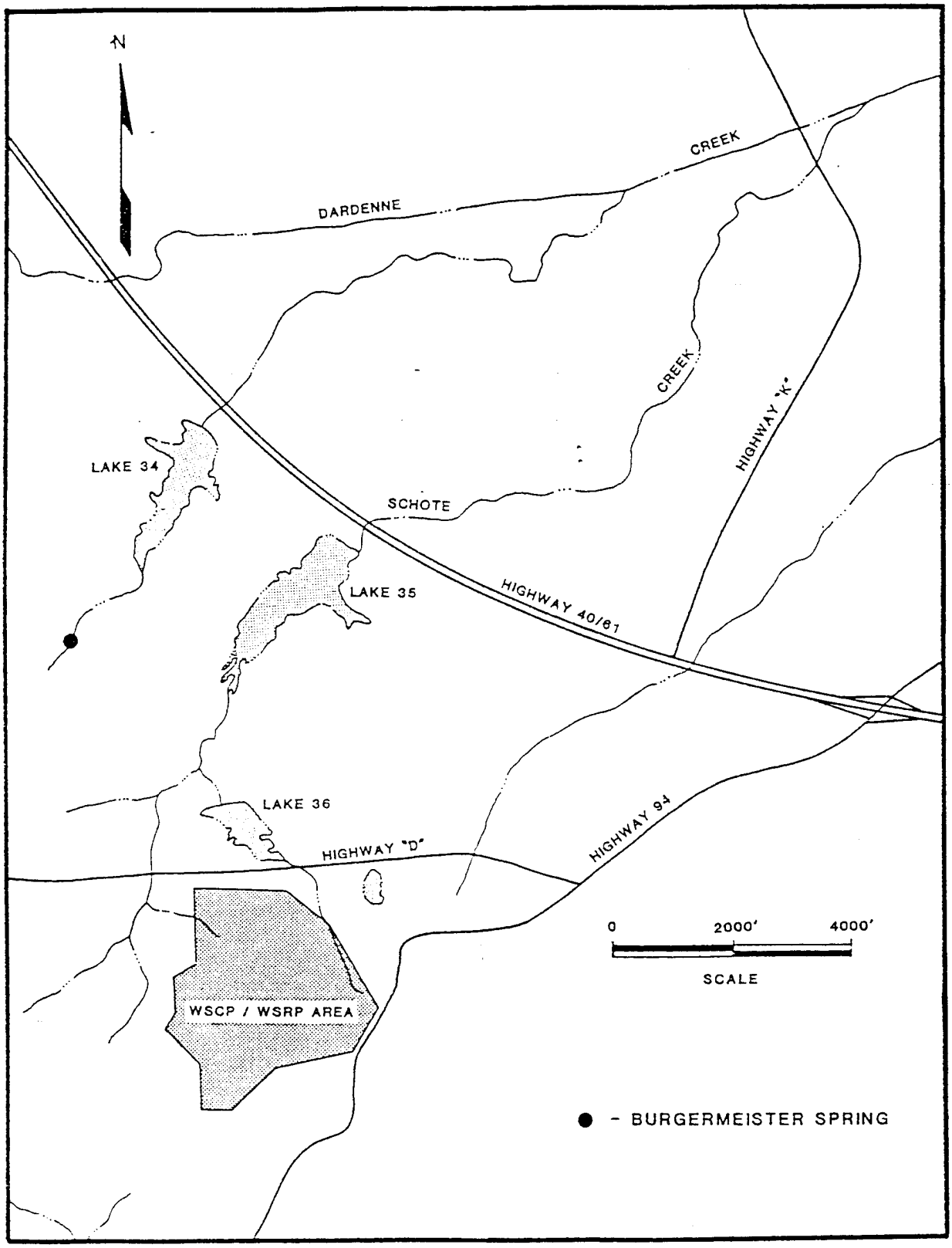


FIGURE 2
MAP OF THE WSCP/WSRP SURROUNDING PROPERTIES

used for recreational activities such as fishing and boating but not as drinking water or irrigation sources.

On the southeast corner of the WSCP, the outfall of the Imhoff Tank, the former WSCP sanitary sewage system, flows down a drainage ditch to the Missouri River. This drainage contains numerous areas of elevated radionuclide concentrations. Currently, flow through the Imhoff Tank results from the infiltration of storm water inflow to the sewer system. Sanitary wastes no longer enter the sewer system.

The Weldon Spring Quarry (WSQ) is approximately 4 miles to the south-southwest of the WSCP. Radioactive wastes were disposed of in the WSQ by the AEC from 1957 to 1966 (Figure 3). The DA also disposed of TNT process wastes into the WSQ. A large portion of the AEC radioactive wastes were from Mallinckrodt Chemical Works' Destrehan Street Feed Plant in St. Louis. Materials from this plant were contaminated with radionuclides in the uranium transformation series.

The Femme Osage Slough is located in the Weldon Spring Wildlife Area, approximately 500-feet SSE of the WSQ sump in an unrestricted area (Figure 3). The sump is believed to be hydraulically connected to the slough. The slough is not used as a source for drinking water or irrigation, but is frequently used for fishing (Figure 4).

Lake 37, located at the western end of the Busch Wildlife Area, will be used as a background location for fish and frog samples. This lake does not receive runoff from either the Army Ordnance Works or the Weldon Spring site and should therefore be free of contaminants. In addition, Lake 37 is generally upwind of the Weldon Spring site and over three miles away.

Average radioactivity levels in surface and runoff water samples taken from in and around the WSS in 1986 are presented in Table 1. These average values are presented in the WSS 1986 Environmental Monitoring Report. The data represents samples taken at quarterly intervals which are then averaged over the entire year. The activity levels in waters will decrease with the increase of distance from site mainly due to dilution by lake waters and/or other water sources.

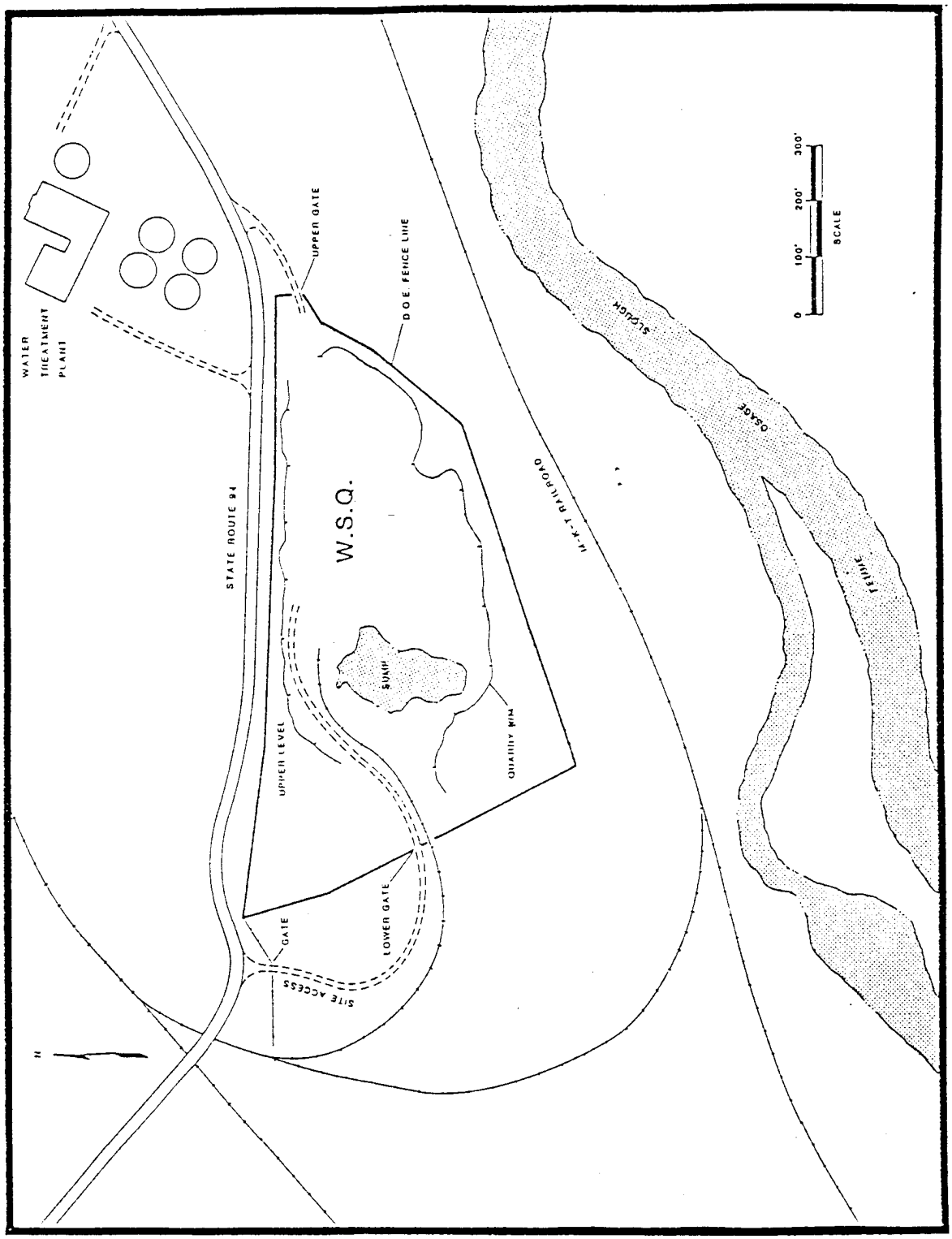


FIGURE 3
MAP OF WSQ

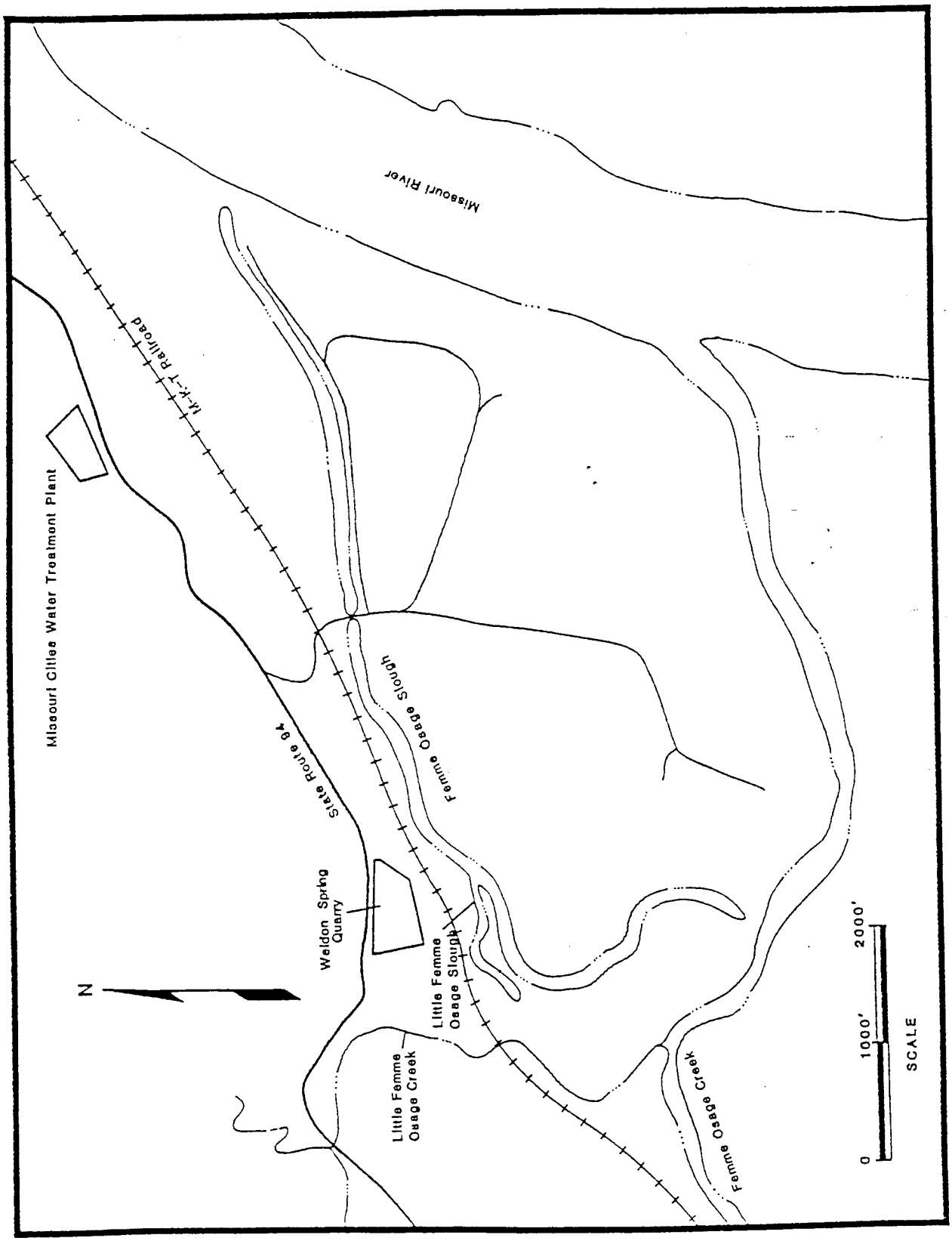


FIGURE 4
MAP OF WSQ SURROUNDING PROPERTIES

TABLE 1

RADIONUCLIDE CONCENTRATIONS FROM 1986 ENVIRONMENTAL MONITORING DATA.

LOCATION	RADIONUCLIDE CONCENTRATIONS (pCi/l)		
	TOTAL U	Ra-226	Th-230
Lake 34	17	0.28	0.20
Lake 35	11	0.18	0.25
Lake 36	36	0.13	0.18
Frog Pond Outfall	29	0.20	1.37
Ash Pond Outfall	2700	0.10	0.0
Raffinate Pit #3	110	160	3.0
Raffinate Pit #4	1900	77	160
Femme Osage Slough	54	0.31	0.28
Quarry Sump	1240	1.0	1.5
Ash Pond	3000	<1.0	<2.0
Frog Pond	30	0.33	1.37

SOURCE: EMR, 1986; 1987

3.0 SAMPLE COLLECTION

Biota samples will be collected from locations both on and off the WSS. Locations of fish, frog, and small mammal collection areas are shown in Figures 5, 6, 7, and 8. Fish will be collected using electrofishing methods and minnow traps, while small mammals will be collected using live traps.

Electrofishing involves the use of a gas powered electric generator to introduce an electric current into the water near the boat. This temporarily stuns fish long enough to be netted and placed in a container in the boat. Electrofishing will be conducted by Missouri Department of Conservation (MDOC) personnel for all sites located on the Busch and Weldon Spring Wildlife Areas. Electrofishing will continue at each site until a sufficient quantity of fish is collected to fulfill the sample requirements. (Table 2)

Five composite samples will be collected, if possible, at each of the offsite locations. Three of the five composites will be composed of filleted specimens representing the following fish; largemouth bass, sunfish, and catfish. These three composites will represent only edible portions of fish tissue. In Lake 35, the largemouth bass composite will be replaced by crappie since this lake has an overabundance of crappie and few bass. It is currently being managed with special regulations to reverse this trend. The fourth composite will consist of sunfish that have

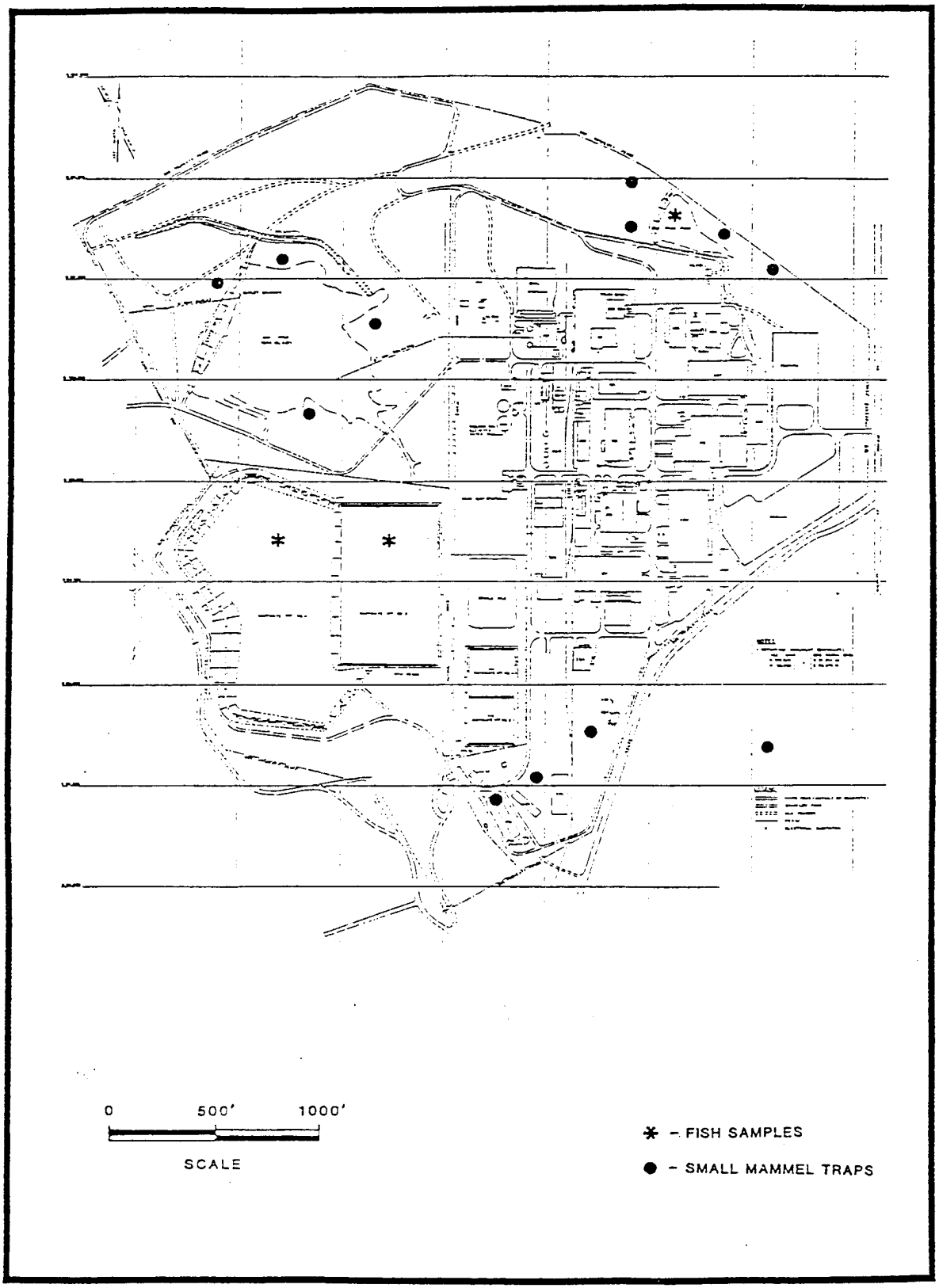


FIGURE 5
MAP OF WSCP/WSRP SAMPLING LOCATIONS

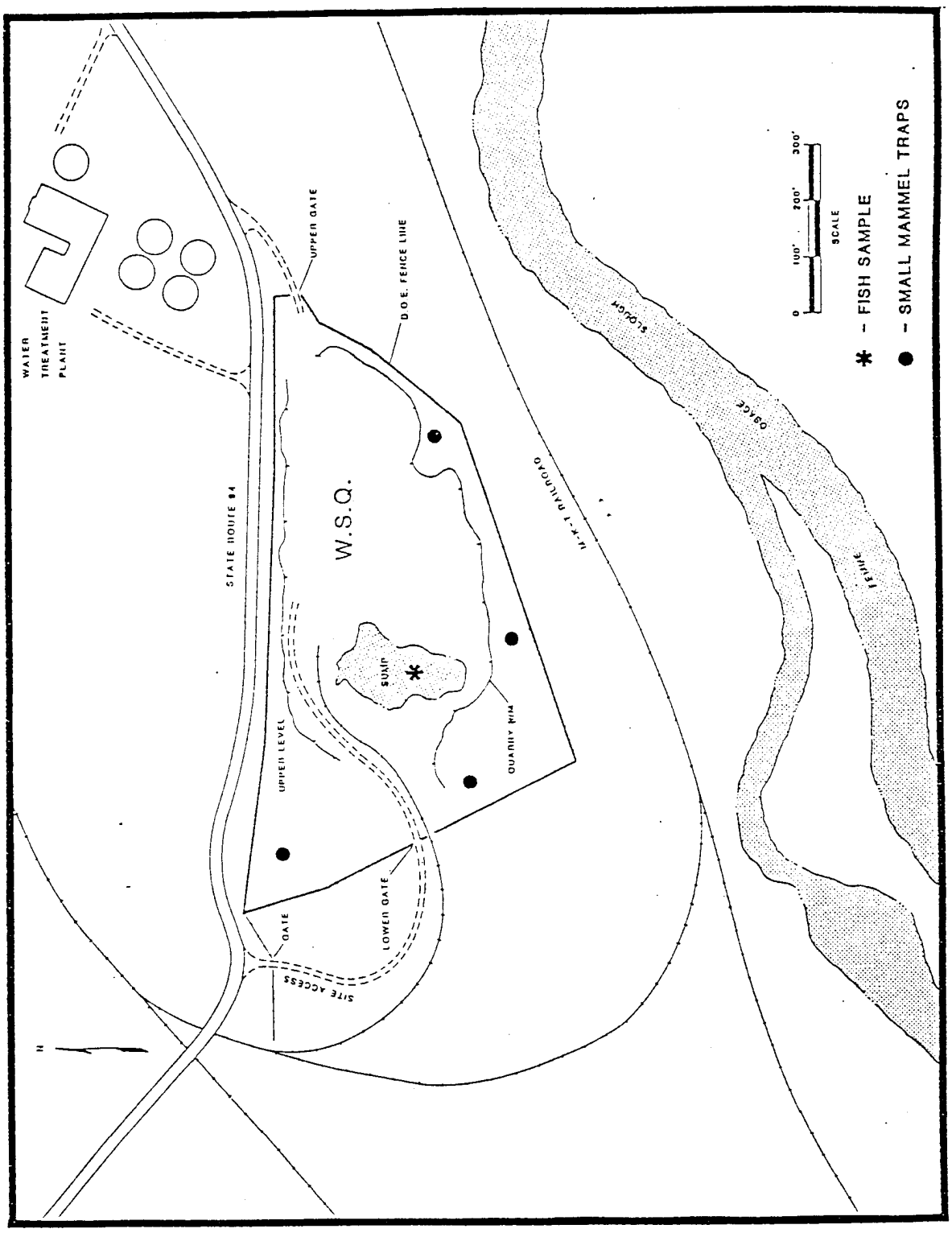


FIGURE 6
WSQ SAMPLING LOCATIONS

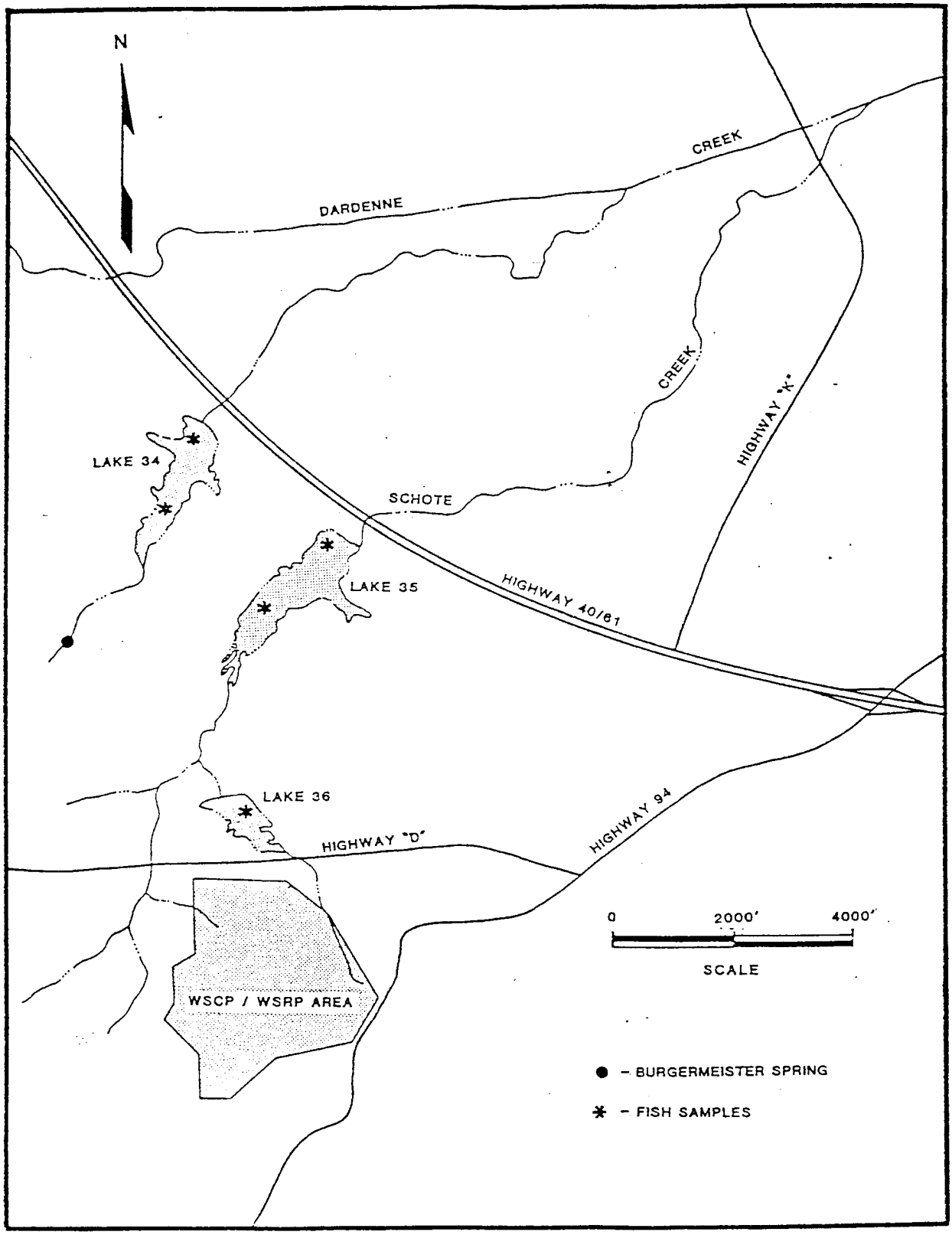


FIGURE 7
WSCP/WSRP SURROUNDING PROPERTIES SAMPLING LOCATIONS

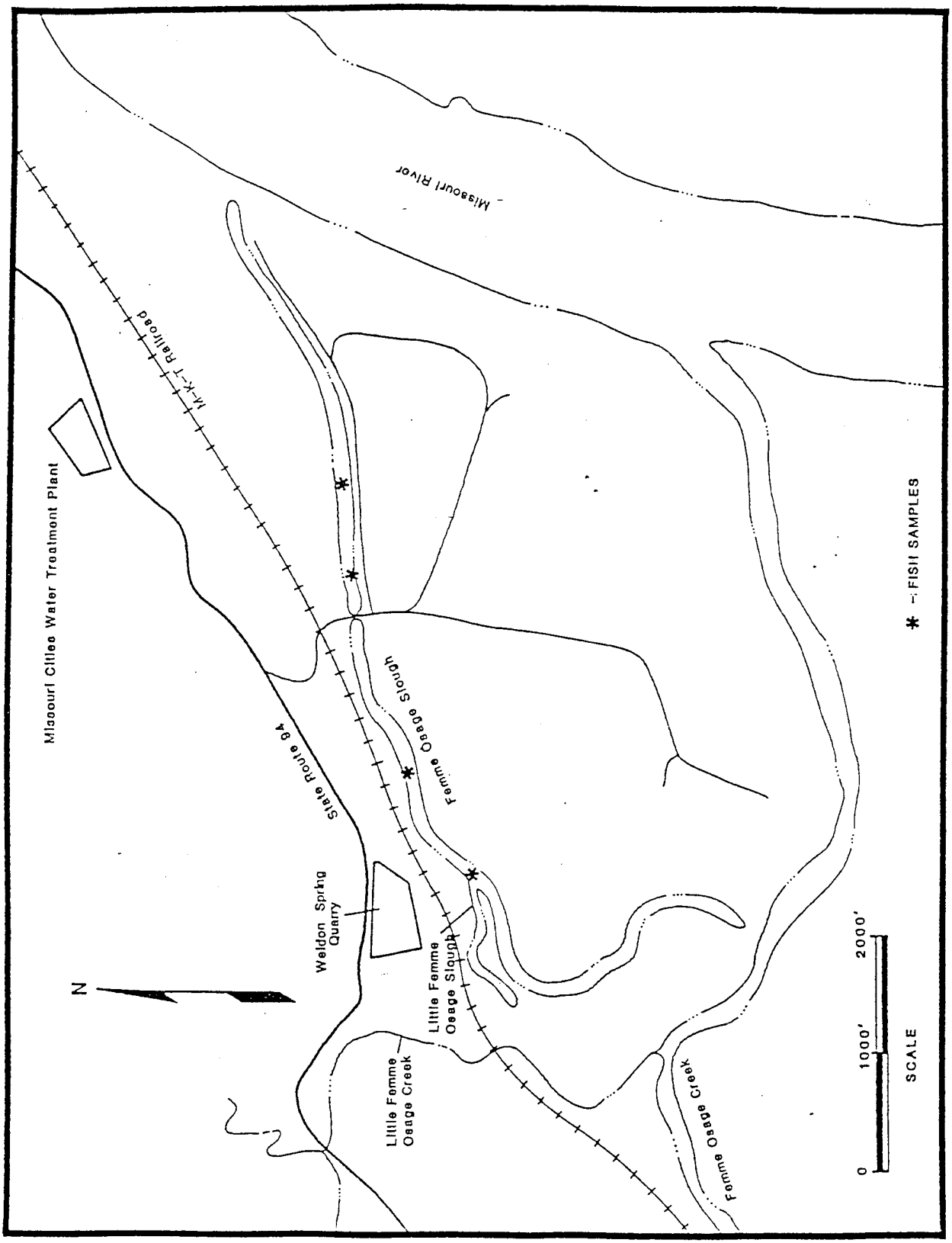


FIGURE 8
MAP OF WSQ SURROUNDING PROPERTIES SAMPLING LOCATIONS

TABLE 2
DESCRIPTION OF SAMPLES COLLECTED

AREA	SPECIES	MINIMUM AMOUNT OF SAMPLE COLLECTED	MINIMUM AMOUNT OF SAMPLE SUBMITTED
Lake 34	Largemouth bass, fillets	(2) 2000 g	(2) 800 g
	Sunfish, fillets	(2) 2000 g	(2) 800 g
	Catfish, fillets	(2) 2000 g	(2) 800 g
	Sunfish, cleaned	(2) 1200 g	(2) 800 g
	Frogs (legs)	3000 g	300 g
	Fish Composite, fillets	(2) 2000 g	(2) 800 g
Lake 35	Crappie, fillets	(2) 2000 g	(2) 800 g
	Sunfish, fillets	(2) 2000 g	(2) 800 g
	Catfish, fillets	(2) 2000 g	(2) 800 g
	Sunfish, cleaned	(2) 1200 g	(2) 800 g
	Frogs (legs)	3000 g	300 g
	Fish Composite, fillets	(2) 2000 g	(2) 800 g
Lake 36	Largemouth bass, fillets	2000 g	800 g
	Sunfish, fillets	2000 g	800 g
	Catfish, fillets	2000 g	800 g
	Sunfish, cleaned	1200 g	800 g
	Frogs (legs)	3000 g	300 g
	Fish Composite, fillets	2000 g	800 g
Frog Pond	Sunfish, fillets	2000 g	800 g
	Catfish, fillets	2000 g	800 g
	Frogs (legs)	5000 g	500 g
Raffinate Pit #3	Minnows, whole	2000 g	800 g
Raffinate Pit #4	Sunfish, fillets	2000 g	800 g
	Catfish, fillets	2000 g	800 g
	Sunfish, cleaned	1200 g	800 g
	Frogs (legs)	5000 g	500 g
Femme Osage Slough	Largemouth bass, fillets	(2) 2000 g	(2) 800 g
	Sunfish, fillets	(2) 2000 g	(2) 800 g
	Catfish, fillets	(2) 2000 g	(2) 800 g
	Sunfish, cleaned	(2) 1200 g	(2) 800 g
	Frogs (legs)	3000 g	300 g
	Fish Composite, fillets	(2) 2000 g	(2) 800 g
Quarry Sump	Catfish, fillets	2000 g	800 g
	Sunfish, fillets	2000 g	800 g
	Frogs (legs)	5000 g	500 g
	Fish Composite, fillets	2000 g	800 g

TABLE 2 (Continued)

AREA	SPECIES	MINIMUM AMOUNT OF SAMPLE COLLECTED	MINIMUM AMOUNT OF SAMPLE SUBMITTED
Lake 37 (Background location)	Sunfish, fillets	2000 g	800 g
	Catfish, fillets	2000 g	800 g
	Largemouth bass, fillets	2000 g	800 g
	Sunfish, cleaned	1200 g	800 g
	Frogs (legs)	5000 g	500 g
	Fish Composite, fillets	2000 g	800 g
Ash Pond Area	Rabbit	1600 g	800 g
	Squirrel	1600 g	800 g
Quarry Area	Rabbit	1600 g	800 g
	Squirrel	1600 g	800 g
Frog Pond Area	Rabbit	1600 g	800 g
	Squirrel	1600 g	800 g
Imhoff SE Drainage Easement	Rabbit	1600 g	800 g
	Squirrel	1600 g	800 g

A total of 65 samples will be submitted.

been cleaned and scaled but not filleted. This composite will represent fish used to make fishcakes, a common method of preparation for small edible fish. The fifth composite sample will be made up of representatives of all species collected, equally represented by weight. These samples will be filleted and analyzed for PCB's and CLP metals.

Locations that will be sampled on-site include Frog Pond, the quarry sump, and Raffinate Pits 3 and 4. While fish have been sited at some onsite surface bodies, it is uncertain that sufficient samples can be collected positively known to occur in these on-site waterbodies. Electrofishing will therefore be utilized in an attempt to obtain samples from these locations. In addition, minnow traps will be set so that a composite sample of whole minnows can be collected if larger fish are unavailable. Some type of fish sample from on-site locations is important since this represents a "worst case" situation of a high radionuclide uptake.

Two separate fish sampling locations have been selected at Lakes 34 and 35 on the Busch Wildlife Area due to the large size of these lakes. The locations are at the inlet and outlet ends of these two lakes. This is being done to see if there is any dilution factor or difference in fish uptake. Higher concentrations might be expected at or near the inlets. Lakes 36 and 37 will be sampled only at the inlet ends. Lake 37 has been chosen for use as a background location. This lake does not receive runoff from either

the WSCP or the DA Ordnance Works abandoned facility.

Two locations will also be sampled in the Femme Osage Slough. The first location is just below the WSQ near the confluence of the Little Femme Osage Slough. The second location is in the eastern end of the Femme Osage Slough on the other side of the access road crossing the Slough (see Figure 8).

4.0 METHODS OF ANALYSIS

Approximately 100 grams of fish tissue per sample will be required for the laboratory analyses per radionuclide. Fish will be cleaned or filleted, depending on the sample, at the end of each day. Fish samples will be stored in labeled plastic bags and frozen prior to shipment to the lab for radionuclide analysis. The composite samples that will be analyzed for PCB's and CLP Metals will be stored in aluminum foil instead of plastic bags. At the laboratory, each composite will be homogenized and extracted as required for the specific analyses to be performed. A summary of the appropriate analysis to be performed on samples are presented in Table 3.

Samples of frogs will be collected from each of the water-body locations. Frogs will be collected using hand-held nets. If this sampling cannot be accomplished in daylight, it will be attempted at night with lights. This method is often used by sportsmen to gig frogs. Frog specimens will be prepared by removing the legs, skinning them, and cutting the meat from the bones. These samples will represent the edible portion of frog tissue. Samples will be bagged, labeled and frozen prior to shipment to the laboratory.

Small game mammals, such as squirrels and rabbits, will be collected by live traps set at various locations around the

Table 3

DESCRIPTION OF SAMPLES COLLECTED AND THE APPROPRIATE ANALYSIS

AREA	SPECIES	TOTAL URANIUM	Ra-226 & Th-230	PCB's & METALS
Lake 34	Largemouth bass, fillets	X		
	Sunfish, fillets	X		
	Catfish, fillets	X		
	Sunfish, cleaned	X		
	Frogs (legs)	X		
	Fish Composite, fillets			X
Lake 35	Crappie, fillets	X		
	Sunfish, fillets	X		
	Catfish, fillets	X		
	Sunfish, cleaned	X		
	Frogs (legs)	X		
	Fish Composite, fillets			X
Lake 36	Largemouth bass, fillets	X		
	Sunfish, fillets	X		
	Catfish, fillets	X		
	Sunfish, cleaned	X		
	Frogs (legs)	X		
	Fish Composite, fillets			X
Frog Pond	Sunfish, fillets	X	X	
	Catfish, fillets	X	X	
	Frogs (legs)	X	X	
Raffinate Pit #3	Minnows, whole	X	X	
Raffinate Pit #4	Sunfish, fillets	X	X	
	Catfish, fillets	X	X	
	Sunfish, cleaned	X	X	
	Frogs (legs)	X	X	
Femme Osage Slough	Largemouth bass, fillets	X		
	Sunfish, fillets	X		
	Catfish, fillets	X		
	Sunfish, cleaned	X		
	Frogs (legs)	X		
	Fish Composite, fillets			X
Quarry Sump	Catfish, fillets	X	X	
	Sunfish, fillets	X	X	
	Frogs (legs)	X	X	
	Fish Composite, fillets			X

Table 3 (Continued)

DESCRIPTION OF SAMPLES COLLECTED AND THE APPROPRIATE ANALYSIS

AREA	SPECIES	TOTAL URANIUM	Ra-226 & Th-230	PCB's & METALS
Lake 37 (Background location)	Sunfish, fillets	X	X	
	Catfish, fillets	X	X	
	Largemouth bass, fillets	X	X	
	Sunfish, cleaned	X	X	
	Frogs (legs)	X	X	
	Fish Composite, fillets			X
Ash Pond Area	Rabbit	X	X	
	Squirrel	X	X	
Quarry Area	Rabbit	X	X	
	Squirrel	X	X	
Frog Pond Area	Rabbit	X	X	
	Squirrel	X	X	
Imhoff SE Drainage Easement	Rabbit	X	X	
	Squirrel	X	X	

Weldon Spring Site. Traps located on the WSCP and WSQ will be focused at boundary areas where animals can migrate on and off site being accessible to hunters. Figure 5 shows the proposed locations where traps will be set in the WSCP area (Frog and Ash Pond). Figure 6 illustrates the locations for the WSQ area.

Live traps will be set in the approximate locations shown on the figures where suitable habitat exists. Traps will be baited and checked daily until the sampling effort has been completed. Only small mammals commonly eaten by hunters will be kept. Others, such as opossums and raccoons, will be released unharmed. Animals kept for analysis will be killed using a pellet gun at close range, skinned, and cleaned, so that tissue samples represent only edible portions.

Each small mammal composite sample will consist of a minimum of 3 individuals. At the WSQ and southeast drainage easement locations, rabbits will probably be difficult to obtain since these locations are densely wooded with little open or brushy habitat suitable for rabbits. Should this be the case, the rabbit composites from these two locations will be deleted.

Small mammal composite samples will be handled in a similar manner as the fish. Composites will be made after skinning and cleaning the animals. The animals will then be stored in

labeled plastic bags and frozen prior to shipment to the lab. Chain of Custody records will be utilized for a written record of the sampling effort. These records will verify that the samples were not tampered with or altered prior to laboratory analysis.

The analysis for uranium, radium, and thorium should have a lower limit of detectability of 0.01 pCi/g. The level of uranium activity in soft tissues is expected to be slightly above this range from the offsite waterbodies. Polychlorinated biphenyls (PCB's) and metals analyses only require 25 and 5 grams for analysis respectively and have a lower limit of detectability in water as listed below:

METALS	DETECTION LEVEL (ug/L or ppb)
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5000
Chromium	10
Cobalt	50
Copper	25
Iron	100
Lead	5
Magnesium	5000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5000
Selenium	5
Silver	10
Sodium	5000
Thallium	10
Vanadium	50
Zinc	20

PCB'S	DETECTION LEVEL (ug/L or ppb)
PCB-1016	0.5
PCB-1221	0.5
PCB-1232	0.5
PCB-1242	0.5
PCB-1248	0.5
PCB-1254	1.0
PCB-1260	1.0

Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) Test Method 608 will be used to analyze samples for PCB's. This is a gas chromatographic (GC) method applicable to the determination of the compounds listed above.

EPA-CLP method for inorganic analysis based on Caucus Inorganics Protocol will be used to analyze samples for Metals. These metals are determined by inductively coupled plasma emission or Atomic Absorption Spectroscopy.

Uranium will be analyzed per EPA Method 908-ASTN. Radium-226 will be analyzed per EPA Methods 903.0 and 903.1. Thorium-230 will be analyzed per the procedure developed by the EPA Eastern Environmental Radiation Facility (EERF 00/07).

5.0 DATA ANALYSES

The set of data along with assumptions made on dietary intake will be used to calculate the radiation dose from internally deposited radionuclides. Cumulative risk estimates from lifelong intakes will assume a linear dose-response relationship for cancer induction at environmental levels.

Important considerations for determining body content of a radionuclide after it is ingested are time and age dependence of the intake. For purposes of the present analysis, it may be assumed that animal and fish tissue concentrations remain constant at an equilibrium value with a fixed daily intake of contaminant. The consumption of these biota by humans will have the same assumptions applied. Since dietary composition and its source can change, this may lead to a conservative oversimplification. Also, some of the metabolic parameters may change due to age dependence over the course of intake. The present analysis will assume metabolic parameters of reference man (ICRP No. 23).

The International Commission on Radiological Protection has developed mathematical models which determine body content of a radionuclide after it is ingested. The bone is the major site for uranium, radium, and thorium accumulation. The biological turnover or half life of a fraction of these is slow, therefore, skeletal cancer will be regarded as the major

potential radiobiological effect of ingestion by humans. The metabolism of the biota and the concentration of the contaminant in their tissue has the primary effect in these calculations. The primary focus will be given to the careful dissection and sample analysis of only food parts from the biota to determine the biota uptake. There is a wealth of data for the assumptions made on uptake and the metabolism in human beings. From this study, the action levels adopted to control radiological risk are to limit the likelihood of bone cancer induction for the nearby population, though calculations will be based on a hypothetically maximum exposed individual.

The quantitative relationship between uranium intake and kidney damage have been measured in several species of animals. Proximal renal tubule cells are killed by high acute or lower chronic dosages of soluble uranium compounds. The limiting concentration for chronic intake is 110 ug per day (Wrenn, 1985). From this level of intake, the toxic effects should be sufficiently low to nonexistent in the kidney. Kidney damage may be expected to occur gradually above this uranium concentration.

Radiobiological Effects of Uranium

The concentration determined in the fish tissue will be multiplied by 4086 grams per year (USDA, 1986) to give the total activity ingested by a hypothetical individual in a one

year time interval. Using the methodology described in ICRP's 26 and 30, the 50-year committed dose equivalent and effective dose equivalent will be calculated.

Example: The Effective Dose Equivalent for a hypothetically exposed individual who consumes fish tissue contaminated with uranium. Assume 1.0 pCi/g total Uranium in fish tissue is found by laboratory analysis :

Radiobiological Dose (mrem) = (1.0 pCi/g) X (4086 g)
X (1.0E-06 uCi/pCi)
X (0.25 rem/uCi) X (1.0E+03 mrem/rem)
= 1.0 mrem (whole body) or 1.0 E-05 Sv.

Example: The 50-year Committed Dose Equivalent to the bone for a hypothetically exposed individual. Assume 1.0 pCi/g total uranium in fish tissue is found by laboratory analysis:

Radiobiological Dose to Bone (mrem) = (1.0 pCi/g) X (4086 g)
X (1.0 E-06 uCi/pCi) X (4.2 rem/uCi)
X (1.0 E+03 mrem/rem) = 17 mrem (bone) or 1.7E-04 Sv.

The radiosensitive cells in bone have been identified as the endosteal cells and epithelial cells on bone surfaces. For purposes of radiation protection, the number of excess cancer

fatalities for bone cancer is 5 per 10000 individuals per Sievert (Sv) (ICRP No. 26).

Example: Bone cancer risk

Bone cancer fatalities per 10000 exposed individuals =

(1.7 E-04 Sv) X (5 fatalities/Sv)

= 9.0 E-04 fatalities/10000 individuals exposed to this level.

The number of excess cancer fatalities is dependent upon the number of individuals consuming 4086 grams of fish from a contaminated lake. If 100 million individuals caught fish from a lake with this amount of contaminant in the fish tissue, then 9 of these individuals would die of bone cancer.

Chemical Toxicity Effects of Uranium

The concentration determined in the fish tissue will be multiplied by 11.2 grams per day (USDA, 1986)* to give the average intake. Gastrointestinal absorption of uranium as a function of intake will decrease with increases in intake. Therefore, a daily average or chronic intake is used for conservatism in these calculations.

According to recent studies, the fractional gastrointestinal (GI) absorption from the GI tract to the blood is 1.4 percent.

* Rabbit, squirrel and frog - assume 2000 grams per year.

A blood-to-kidney transfer factor of 11 percent (Wrenn, 1985) is assumed, with a 15-day half-time in the kidney. The amount of uranium in the kidney at equilibrium would then be as follows:

$$A_e = (f_1/\ln 2) \times (f_{21})\ (T_1) = (0.014/\ln 2) \times (0.11)(15)$$
$$= 0.033 \text{ or } 3.3 \text{ percent}$$

where: A_e = amount of uranium in the kidney at equilibrium
f_1 = fractional GI absorption from GI tract to blood
f_{21} = fractional transfer from blood to kidney
T_1 = half-time in kidney compartment

Using 0.6 ug/g as the limiting concentration (C_L) in the kidney (below the injury threshold, Wrenn, 1985), a safety factor(S) of 50(NAS-77) and kidney mass (m= 310 g), the limiting daily intake (I_L) would be derived as:

$$I_L = (C_L/S)(A_e/m) = (0.6/50)/(0.033/310)$$
$$= 110 \text{ ug per day}$$

If the measured concentration in the fish tissue is 1.0 pCi/g then the percent of the limiting daily intake would be calculated as:

$$I_L\% = \frac{(C) \times (CF) \times (A) \times 100\%}{I_L}$$

$$= \frac{(1.0 \text{ pCi/g})(0.677 \text{ ug/pCi})\ (11.2 \text{ g}) \times 100\%}{110 \text{ ug}}$$

$$= 7\%$$

where: C = Assumed concentration in fish tissue

CF = Conversion Factor for a mass of natural uranium to its activity

A = Amount of fish tissue ingested daily

I_L = Limiting Daily intake

Nitroaromatic Toxicity Effects

Available data pertaining to DNT and TNT exposure is limited at this time. Animal studies indicate significant species and strain differences in the excretion of DNT isomers. There is growing evidence from research that DNT's are carcinogenic, although the potency of the different isomers in cancer induction is not well characterized. The primary site for TNT toxicity is the blood system and liver. The most serious systemic effects of acute TNT poisoning in humans are toxic jaundice and toxic hepatitis.

The potency of DNT varies in studies, so to assure the protection of public health from carcinogenic effects, a 10^{-6} cancer risk level has been assumed by the EPA at the dosage of 6.4×10^{-7} mg/kg/day. Since studies have provided no evidence of TNT carcinogenicity, an Allowable Daily Intake (ADI) has been used for a no-observed-adverse-effect level at 1.4×10^{-3} mg/kg/day.

By comparing actual contaminant levels with these criteria, the actual risks incurred from ingestion of biota tissue containing these nitroaromatics could be estimated. The development of criteria is still based on a variety of conservative assumptions and safety factors so that no adverse health effects would be expected.

At the WSS, determinations regarding the levels of contamination in water are being reviewed and studied. Again, until the different TNT and DNT isomers are better characterized and the breakdown products in tissues reviewed for carcinogenic effects, contaminant levels in tissues along with the variety of assumptions and safety factors will make the criteria and an acceptable risk far lower than the present day detection limits for these nitroaromatics in tissues.

Discussion

If the biota sampling results in significant findings, routine collection and analysis may be added to the Environmental Monitoring Plan. The radiation dose calculated from edible parts of biota samples and measured data for water concentrations will be compared. The chemical toxicity and percent of Limiting Daily Intake from edible parts will be reviewed. The findings from this program will be summarized and interpreted in the Endangerment Assessment section of the RI/FS.

If measured offsite concentrations increase and conditions change significantly in future operations, the need may arise for additional studies. Sampling efforts at onsite locations with higher radionuclide concentrations may provide better estimates and determinations for outcomes of such releases.

The DOE radiation dose limit for an unrestricted area is 100 mrem/yr above background for whole body exposure. The DOE Administrative action level is 25 mrem/yr above background. A hypothetical individual consuming such biota from the vicinity of WSS would receive internal exposure via the food pathway and by ingestion of contaminated water. If calculations suggest the radiation dose to an individual is greater than 50 percent of the administrative action level, then biological sampling will be included in the Environmental Monitoring Plan based on radiological concerns.

An administrative action limit for chemical toxicity to uranium has not been developed. If calculations suggest the chemical toxicity to an individual is significant, then biological sampling will be included in the Environmental Monitoring Plan based on chemical toxicity concerns.

In the Appendix, Table A-1 lists the estimated costs for laboratory analysis of the samples. An increase in cost is due to a much lower limit of detection required in the analyses of radionuclides. The total number of man-hours required to

complete the sampling, mobilization of equipment, and sample preparation are estimated in Table A-2 in the Appendix. MDOC will be supplying equipment and personnel for the sampling on the Busch Wildlife Area, however, sampling on the WSS will require the use of Project equipment and materials. A list of the necessary equipment and materials needed for the entire sampling operation are listed in Table A-3 in the Appendix.

6.0 References:

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Wang, J. et.al. Potential Radiological Impacts Associated with Release of Contaminated Water from the Weldon Spring Ash Pond and Burgermeister Spring. ANL, Argonne, IL 1986.

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APPENDIX

Table A-1

The Laboratory Analyses With Unit Costs

TYPE OF ANALYSIS	UNIT COST	ESTIMATED NUMBER
Total Natural Uranium	120.00	59
Radium-226	200.00	24
Thorium-230	200.00	24
CLP-Metals	300.00	9
PCB's	150.00	9

Table A-2

Estimated Amount Of Time Required
To Complete The Sampling Operation

AREA	MAN-HOURS
Lake 34 *	24
Lake 35 *	24
Lake 36 *	24
Lake 37 *	24
Frog Pond	24
Raffinate Pit #3	24
Raffinate Pit #4	24
Femme Osage Slough *	36
Quarry Sump	36
Total Man-Hours	240

* Locations will be assisted by MDOC personnel.

Sampling efforts will begin after September 28, 1987. MDOC personnel will be notified well in advance of operation. Small mammal traps will be set after September 28, 1987. Traps will be checked on a daily basis until minimum sample numbers obtained.

Table A-3

Equipment And Materials Needed For The Sampling Operation

1. Small mammal traps (18)
2. Boat or raft for onsite
3. Electroshock apparatus for onsite
4. Small mammal dissection kits
5. Fish filet equipment
6. Sample collection bags
7. Radiation monitoring equipment
8. Life preservers
9. Rubber boots & gloves
10. Rain suits
11. Transport for boat or raft
12. Sample prep table
13. Waste containers
14. Permits